

LM-BFS: A Framework for Landmarks in Planning

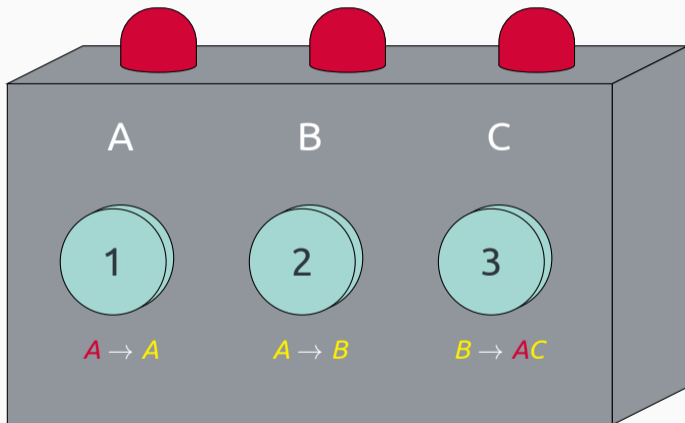
Clemens Büchner and Thomas Keller

HSDIP at ICAPS 2021

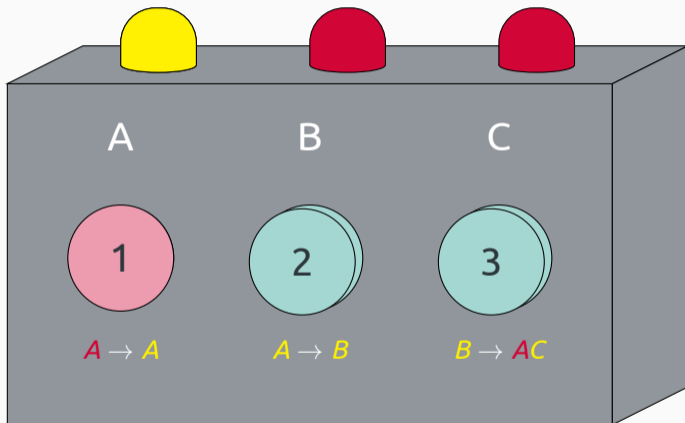


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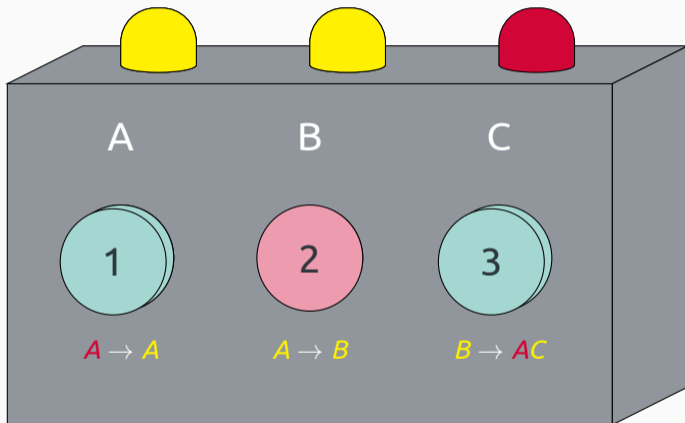
Introduction



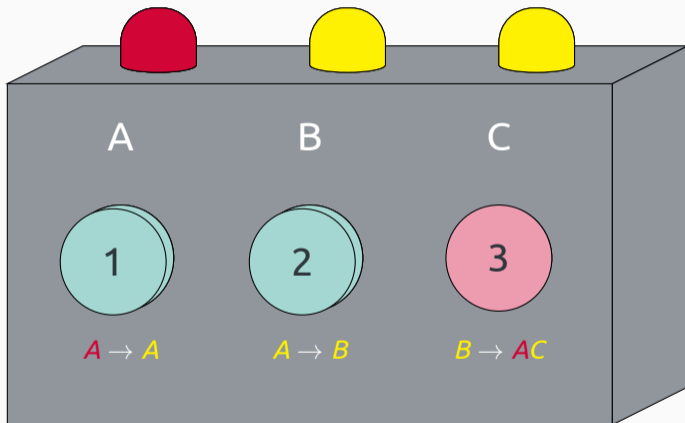
Introduction



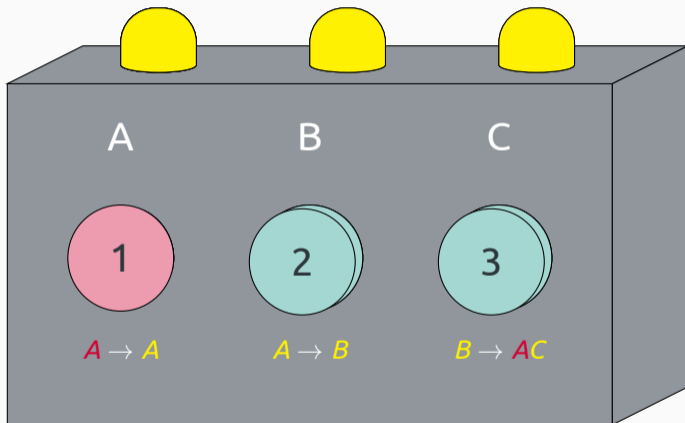
Introduction



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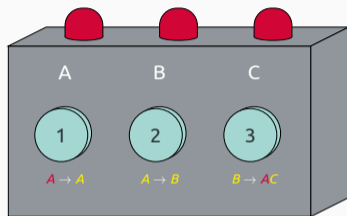
Landmarks

Landmarks

- **must occur** in all plans
 - *A*, *B*, and *C* must glow

Landmark orderings

- all plans **follow specified order**



Landmark graph



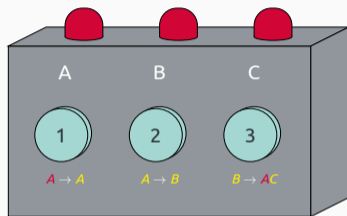
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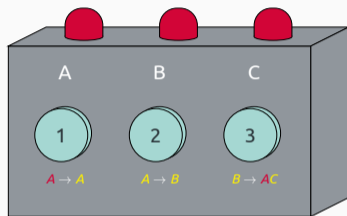
Landmarks

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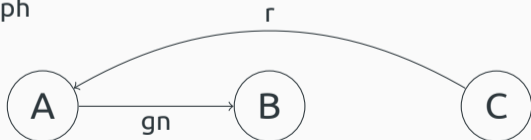
- **must occur** in all plans
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Landmark orderings

- all plans **follow specified order**



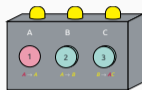
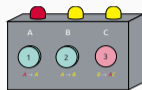
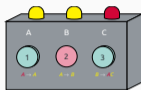
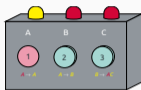
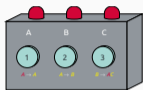
Landmark graph



Planning with landmarks:

1. **compute** landmark graph
2. **progress** landmark graph
3. **merge** landmark graphs
4. **extend** landmark graph
5. **explore** using landmark heuristic

LM-A* (Karpas and Domshlak, 2009)



s_0 :



s_1 :



s_2 :



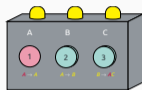
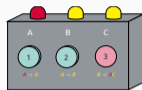
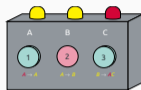
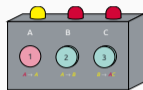
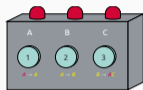
s_3 :



s_4 :



LM-A* (Karpas and Domshlak, 2009)



s_0 :



s_1 :



s_2 :



s_3 :



s_4 :



Progression Rules

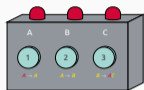
LM-A* and LAMA:

- some landmarks are **required again**
 - **goals** if they do not hold
 - greedy-necessary **preconditions** if they do not hold

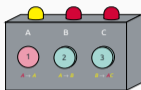
only LAMA:

- do **not accept** landmarks with unaccepted parents

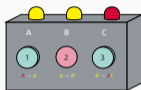
LAMA (Richter and Westphal, 2010)



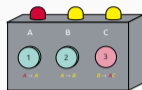
s_0 :



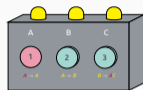
s_1 :



s_2 :



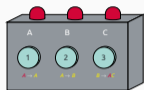
s_3 :



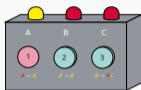
s_4 :



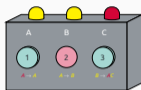
LAMA (Richter and Westphal, 2010)



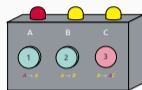
s_0 :



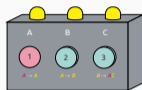
s_1 :



s_2 :



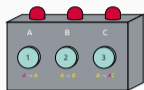
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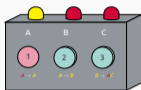
s_4 :



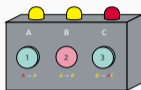
LAMA (Richter and Westphal, 2010)



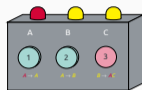
s_0 :



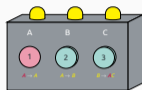
s_1 :



s_2 :



s_3 :



s_4 :



Inadmissibility

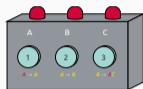
Problem:

- **chain reaction** of unaccepted landmarks

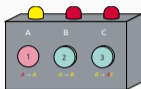
Solution:

- accept all landmarks when **first added**
- mark reasonable successors as **required again**

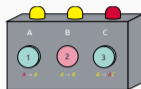
Admissible Reasonable Orders (ARO)



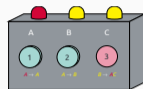
s_0 :



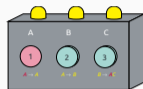
s_1 :



s_2 :



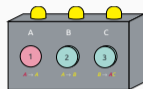
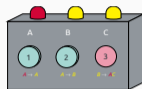
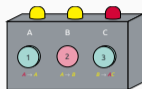
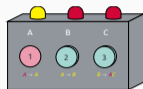
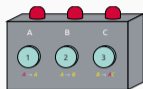
s_3 :



s_4 :



Admissible Reasonable Orders (ARO)



s_0 :



s_1 :



s_2 :



s_3 :

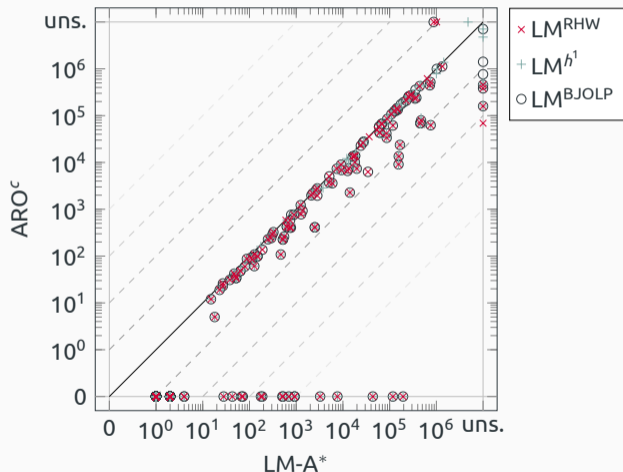


s_4 :



Experiments – Cost-Optimal Planning

Expanded states:



Experiments – Satisficing Planning

Cheaper plans:

| | LAMA | ARO |
|------|--------------|------|
| LAMA | - | 98.0 |
| ARO | 103.4 | - |

Experiments – Satisficing Planning

Cheaper plans:

| | LAMA | ARO | ARO ^c |
|------------------|--------------|--------------|------------------|
| LAMA | - | 98.0 | 352.8 |
| ARO | 103.4 | - | 269.4 |
| ARO ^c | 411.6 | 324.6 | - |

Summary

- **reasonable orderings** hold **valuable information**
- LAMA progression is **inadmissible**

Summary

- **reasonable orderings** hold **valuable information**
- LAMA progression is **inadmissible**
- **cycles** in landmark graphs are **a good thing**